

REMARKS

This Amendment is in response to the Office Action of July 9, 2001. With this response, claims 21 and 22 are amended, pages 8-11 and 16 of the specification are amended and all pending claims 21-34 are presented for reconsideration and favorable action.

With this Amendment, a number of typographical errors are corrected in the specification. Additionally, language is added to page 16 of the specification. Support for this addition can be found in claims 1-20 of the application as originally filed.

As illustrated in the prior art, the use of pads on sliders is known. However, the present invention recognizes that pads which are spaced apart from the trailing edge of the slider can cause the slider to tilt about an axis of the pads such that the trailing edge of the slider comes into close proximity with the disc surface. The present invention further recognizes that this causes a meniscus of lubricant to form between the trailing edge and the disc surface. The present invention reduces this meniscus by using a trench near the trailing edge of the slider which reduces capillary pressure and the area of the meniscus.

In paragraphs 1 and 2 of the Office Action, the Examiner has raised a rejection under 35 U.S.C. § 112. First, the Examiner notes that at page 5, lines 22-24, the specification states that the air bearing surface includes raised side rails. The Examiner noted that claim 21 includes both an air bearing surface and a raised side rail. The raised side rail has been deleted from claim 21 and it is believed that the rejection may be withdrawn. Paragraph 1 also stated that claims are inadequately disclosed under 35 U.S.C. § 112, paragraph 1 if claim 21 is read to encompass more or less than two side rails and one center rail. The raised side rail has been deleted from claim 21 and it is believed that this portion rejection may also be

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withdrawn. Additionally, the additional language at the end of the specification provides support for the air bearing being just that, a bearing. There is no reason that it should be limited to the specific example illustrated in the specification. It is believed that the rejection under 35 U.S.C. § 112 against claims 21-34 may be withdrawn.

In paragraph 2 of the Office Action, claim 21 was stated to be "misleading and misdescriptive." However, it is believed that this language is fully supported by page 5, lines 22-24 of the specification along with the additions to the end of the specification. It is therefore believed that the rejection under 35 U.S.C. § 112 of claim 27 may also be withdrawn.

Claims 21, 23, 24, 27 and 31-34 were rejected under 35 U.S.C. § 102(e) based upon Kasamatsu et al., (5,841,608). Claims 22 and 28 were rejected under 35 U.S.C. § 103 based upon Kasamatsu. Claims 21, 23, 24, 27, 28 and 31-34 were rejected under 35 U.S.C. § 103 based upon Strom (4,802,042) in view of Kasamatsu. Claims 21, 22-24, 27, 28 and 31-34 were rejected under 35 U.S.C. § 103 based upon Ohtsubo (4,646,180) in view of Kasamatsu. Finally, claims 21, 23, 24 and 31-34 were rejected under 35 U.S.C. § 103 based upon Smith et al. (5,086,360) in view of Kasamatsu et al.

Kasamatsu et al. show grooves 32 which extend around projections 30 in Figures 16 and 17. The grooves provided by Kasamatsu are designed to be placed near the projections so that they will hold lubricant collected from the disc surface. (Col. 17, lines 23-30). This section states that during normal operation lubricant is "scattered" and it is for this reason that the grooves are provided to hold the lubricant. This is quite different from the present invention in which it is recognized that pads can cause the slider to tilt such that a meniscus lubricant is developed at the trailing edge of the slider. In fact, the trenches of the present invention are configured to

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"reduce capillary pressure and area of a meniscus due to a disc lubricant proximate the trailing edge." This is the opposite of the configuration of Kasamatsu in which the Kasamatsu grooves are configured to collect lubricant.

Thus, in two aspects the Kasamatsu reference teaches away from the present invention. First, Kasamatsu teaches that the "trenches" should be placed near the "pads." Such a configuration would not be able to affect the meniscus at the trailing edge of the slider because the pad itself would space the trench away from the slider. Further, the grooves of Kasamatsu are designed to collect lubricant which would actually increase the meniscus. Thus, not only does Kasamatsu fail to show or suggest the present invention, it actually teaches away from the claimed invention and at best would have no effect on the meniscus at the trailing edge. At worst, it would exacerbate the meniscus problems associated with the trailing edge meniscus.

The addition of Strom, Ohtsubo or Smith does nothing to overcome the shortcomings of Kasamatsu. These three references all describe grooves which are used for particular air bearing effects. (See Strom, col. 3, line 67 through col. 4, line 10, Ohtsubo, col. 4, lines 25-42 and Smith, col. 5, lines 58-66). These three references appear to be completely silent as to the use of grooves for reducing a meniscus at a trailing edge. Further, there is no suggestion that the teachings of these three references could somehow be used to modify Kasamatsu in order to arrive at the present invention. If the references were combined, perhaps one would arrive at a slider having protrusions along with grooves which provide a particular air bearing effect, such as a negative pressure bearing. There is no reason to think that one would stumble on the configuration set forth in the pending claims.

In view of the above amendments and remarks, it is believed that the present application is in condition for

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allowance. Consideration and favorable action are respectfully requested.

The Director is authorized to charge any fee deficiency required by this paper or credit any overpayment to Deposit Account No. 23-1123.

Respectfully submitted,

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MARKED-UP VERSION OF REPLACEMENT PARAGRAPHS

Replacement paragraph for the paragraph beginning at Page 8, Line 29 and ending at Page 10, Line 5:

The stiction force 114 of the slider 110, 112 relative to the disc surface was measured for each rotation direction. As shown, the stiction 114-1 for slider 110 in the forward rotation direction was significantly less than the stiction 114-2 measured in the backward rotation direction. Similarly, the stiction force 114-3 for slider 112 in the forward direction was significantly less than the stiction force 114-4 measured in the backward rotation direction. The large discrepancy in stiction is attributed to an increase meniscus 106 introduced by the slider tipping as illustrated in FIG. 5 when the slider was subjected to a backward rotation direction of the disc prior to stiction measurement so that the friction force drives the slider towards tipping.

To form the menisci, the lubricant is dragged from the contact area between the slider and disc surface along the surface of the slider (herein capillary surface), via capillary pressure.

The lubricant film is dragged so that the effect of the meniscus expands, while the attractive force between lubricant molecules and the solid surface, which is quantitatively represented by the disjoining pressure of the lubricant film, is overcome by the driving force of the capillary pressure of the meniscus. The magnitude meniscus force F_m and stiction for the slider is proportional to the area of the meniscus. In particular stiction force F_s (in grams-force gf) may be estimated as follows:

$$F_s \approx 0.0005A \quad \text{Eq. 2}$$

where:

A is the area of the meniscus in μm^2 .

For example, every $2,000 \mu\text{m}^2$ of meniscus creates 1gf of stiction. Thus, in the embodiment of the slider 72 illustrated in

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FIGS. 3-4, the center rail 94 is approximately $70,000 \mu\text{m}^2$ and thus if half the center rail is flooded an estimated stiction force is approximately 17.5 gf. The increase stiction force as illustrated above affects operation of the disc drive.

As the lubricant film is thinned, it is more and more difficult for a meniscus to draw lubricant from its surrounding area to spread. Eventually, a (quasi) equilibrium state is reached where the disjoining pressure of the film equals the capillary pressure of the meniscus as follows:

$$\frac{A_H}{6\pi d^3} = \frac{\gamma}{R_e} \quad \text{Eq. 3}$$

where:

A_H is the Hamaker constant

γ - is surface tension of the lubricant;

R_e - is the radius of the leading edge 115 of the meniscus formed between the disc and capillary surface of the slider.

d - is the thickness of the lubricant film.

Replacement paragraph for the paragraph beginning at Page 10, Line 31 and ending at Page 11, Line 12:

In particular, in the toe-dipping regime, illustrated in FIG. 7-1, bumps 116 contact lubricant film 102 developing a meniscus 106 at the interface between the bump 116 and lubricant film 102. The meniscus 106 expands until radius R_e of the meniscus is at equilibrium as defined by Eq. 13. $2R_e$ at equilibrium is less than the separation distance 120 between the slider and the disc so that the meniscus area does not extend or spread between the slider 72 and the disc surface. In the pillbox regime illustrated in FIG. 7-2, $2R_e$ at equilibrium for lubricant thickness d is similar to the separation distance 120 of the head - disc. FIGS. 7-3 and 7-4 illustrate ~~equilibrium~~ equilibrium

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positions where the meniscus film envelopes the separation between the disc and slider so that the slider is essentially glued to the disc surface by the lubricant film.

Paragraph for Page 16, Line 1:

A slider for supporting transducer elements for a data storage system includes a rigid member having opposed leading and trailing edges and opposed upper and lower surfaces. The lower surface includes a raised bearing and a trailing edge surface being adapted to support a transducer element. Landing pads extends from the raised bearing and are adapted to define a contact interface with a disc surface. At least one pressure relief trenches formed in the raised bearing proximate to a contact interface between the trailing edge of the slider and disc surface. The trench is sized to reduce capillary pressure of the meniscus along the disc surface. The slider can include a center rail and the center rail includes a pressure relief trench. The slider can include a transversely aligned pressure relief trench which may be opened at opposed ends thereof to form a through channel. The slider can include a longitudinally aligned pressure relief trench, a sloped pressure relief trench, and a plurality of spaced pressure relief trenches. The slider can include opposed side rails and the side rails include a pressure relief trench. The trench can include a depth dimension sized so that separation of the slider and disc at the trench during contact of the slider with the disc surface is equal to or greater than $2R_e$ to balance capillary pressure and disjoining pressure of a lubricant fluid on the disc surface. The trench can be sized to provide a slider-disc interface in the toe-dipping regime. A slider for supporting transducer elements for a data storage system includes a rigid member having opposed leading and trailing edges and opposed upper and lower surfaces. The lower surface includes raised bearing surfaces and the trailing edge is adapted to support a transducer element. Landing pads extend from

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a bearing surface and are adapted to define a contact interface with a disc surface. Pressure relief means proximate a contact interface position between the trailing edge of the slider and disc surface to reduces capillary pressure of the meniscus to limit area of the meniscus.

MARKED-UP VERSION OF REPLACEMENT CLAIMS

21. (Amended) A slider for supporting a transducer element for a data storage system comprising:

a rigid member including opposed leading and trailing edges and opposed upper and lower surfaces, the lower surface including an air bearing surface;

landing pads extending from the air bearing surface and spaced from the trailing edge of the rigid member ~~to define a contact interface with~~ such that the rigid member tilts about an axis defined by the pads to thereby cause the trailing edge to approach a disc surface; and

~~a raised side rail on the air bearing surface; and~~

at least one pressure relief trench formed in the ~~raised side rail~~ air bearing proximate to the trailing edge of the rigid member and spaced from the landing pads to reduce capillary pressure and area of a meniscus due to a disc lubricant proximate to the trailing edge of the rigid member caused by tilt of the rigid member.

22. (Amended) The slider of claim 21 wherein the ~~rigid member~~ air bearing surface includes a center rail and the center rail includes a pressure relief trench.

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